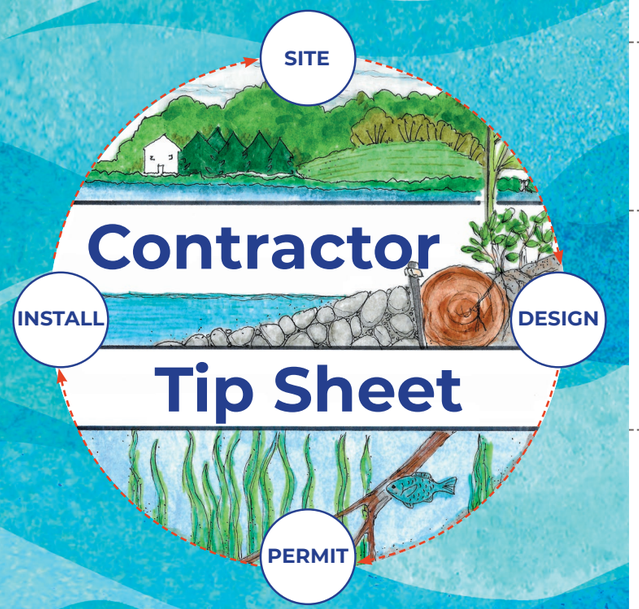
Basic Bioengineering Principles and Practices for Inland Lake Shorelines



A quick reference guide to designing and installing bioengineering projects for healthier lakes.

Tip of the Mitt Watershed Council

MIDWEST GLACIAL LAKES Partnership

Support for this publication provided by a Midwest Glacial Lakes Partnership Lake Conservation Grant

Michigan Natural Shoreline Partnership

Additional resources can be found at:
www.shorelinepartnership.org

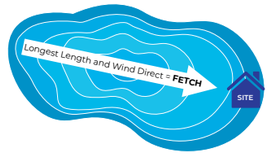
Adapted from: Army Corps of Engineers' Shoreline Protection Manual, Natural Resource Conservation Service's Engineering Field Handbook Chapter 16 Streambank and Shoreline Protection Natural Resources Conservation Service's Technical Note: Slope Protection for Dams and Lakeshores.

Design

WHEN INCORPORATING FIELDSTONE INTO DESIGN, SIZE OF ROCK IS DETERMINED BASED ON WAVE SIZE, WHICH IS CALCULATED BY FETCH AND WIND SPEED.

Fetch

Longest unobstructed, over-water distance across which wind blows before reaching site.



Wind **Speed**

For inland lakes within the Great Lakes Region: Standard design criteria for rock revetments is determined based on significant wave heights generated by 35 MPH average sustained wind, unless otherwise determined.

Significant Wave **Height**

Use the known fetch and wind speed with **Table 1** to estimate significant wave height which is equal to the average height of the largest 1/3 of waves.

TABLE 1: ESTIMATING SIGNIFICANT WAVE HEIGHT (FEET)

FETCH (Miles)	20.0	35.0	50.0
20.0	1.35	2.70	4.70	6.75
15.0	1.20	2.34	4.10	5.80
10.0	0.90	1.90	3.30	4.75
5.0	0.70	1.35	2.35	3.30
2.0	0.40	0.85	1.45	2.15
1.0	0.30	0.60	1.05	1.50
0	10.0	20.0	35.0	50.0

WIND SPEED (MPH)

Median **Rock Size**

Knowing the median rock size is required to determine both the largest and smallest size of rock in a project. Use the known significant wave height and **Table 2** to determine the median rock size.

TABLE 2: DETERMINING MEDIAN ROCK SIZE

SIGNIFICANT WAVE HEIGHT (FEET)	ROCK DIAMETER (IN)
0.5	2.0
1.0	4.5
1.5	6.5
2.0	9.0
2.5	11.0
3.0	13.0
4.0	18.0
5.0	26.0
7.0	48.0

Fieldstone

THE SIZE AND SHAPE OF THE ROCK, THE STRUCTURE, ARRANGEMENT, AND SLOPE OF THE REVETMENT SHOULD FOLLOW THESE DESIGN CRITERIA:

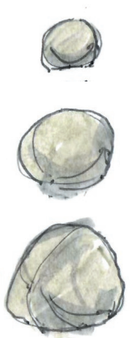
Size, Shape Distribution

Smallest Rock Size

Median size x 0.5
(smallest rock size does not include the drainstone/peastone layer).

Largest Rock Size

Median size x 1.5



25% Smaller than median size

50% Median size

25% Larger than median size

Rocks should be rounded fieldstone, not quarry or angular stone.

Check all local, state, and federal permit requirements for design criteria such as maximum rock size. Designs should be tailored to each site based on proper site assessment.

Toe Stone

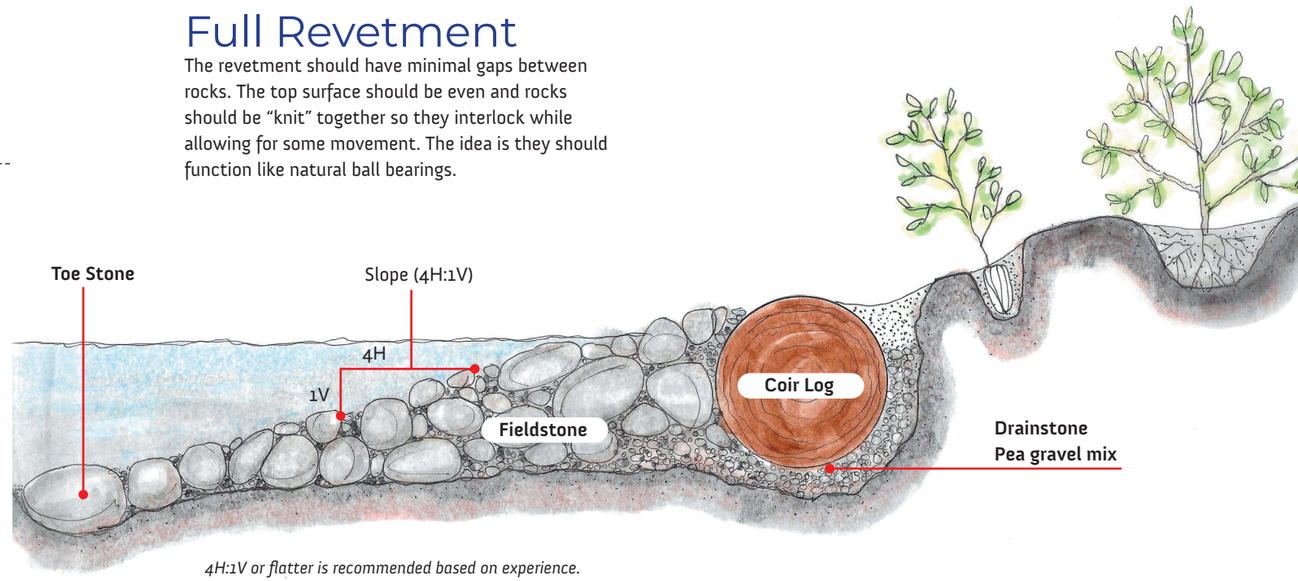
Toe stones should be the largest stones in the revetment. Each stone should be buried so that 1/3 to 1/2 are set within the lake bottom. Positioned so that the flattest side of the rock creates a wedge (avoid a vertical plane, but rather create a slope that establishes the base of the revetment).

Filter Layer

A mix of drainstone and pea gravel should serve as the base of revetment. This layer prevents waves from displacing soils below the fieldstone and coir logs. Several inches of the drainstone/pea gravel should be under the coir logs and extend waterward for 2'-3' and taper at minimum at a slope of 3H:1V -4H:1V (e.g. 3 or 4 foot horizontal to 1 foot vertical slope). Additional drainstone can be used to adjust height of coir log if necessary. Use drainstone/pea gravel to backfill any shoreline cavities and voids between the coir log and shoreline as appropriate.

Full Revetment

The revetment should have minimal gaps between rocks. The top surface should be even and rocks should be "knit" together so they interlock while allowing for some movement. The idea is they should function like natural ball bearings.



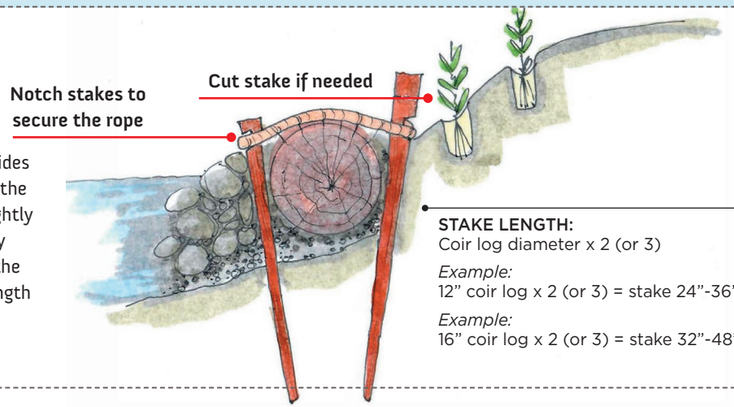
4H:1V or flatter is recommended based on experience.

Coir Logs (aka Biologs)

Coir logs are rolled coconut fiber logs that typically come in diameters of 12", 16", and 20"; lengths of 10' or 20'; and varying densities. Consult manufacturer specifications for appropriate density recommendations. It is important to both properly position (elevation and alignment) and secure them. Select diameter so top of installed coir log closely approximates elevation of bank height.

Securing Coir Logs with **Stakes**

Hardwood stakes should flank each coir log on both sides at 3' intervals. Pound stakes so they are snug against the coir logs until the top of each stake is level or just slightly below the top of the coir log. Stakes should be slightly angled to create a very subtle narrowing underneath the coir log. Stakes should be 2" square and be 2-3X in length as the diameter of the coir logs .



STAKE LENGTH:
Coir log diameter x 2 (or 3)

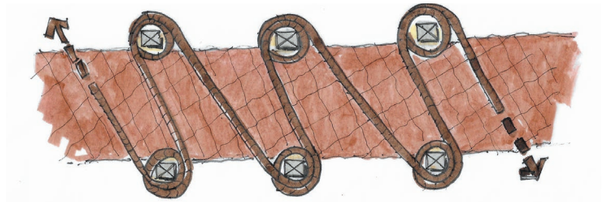
Example:
12" coir log x 2 (or 3) = stake 24"-36" long

Example:
16" coir log x 2 (or 3) = stake 32"-48" long

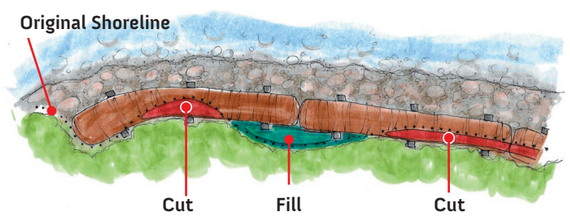
Securing Coir Logs with **Twine**

Using coir or jute twine, lash coir logs to stakes by creating a back and forth pattern from one stake to the next while lacing through the top of the coir log between mesh openings. Lashing should be tight, continuous and tied off to prevent unraveling.

Plan view



Plan view



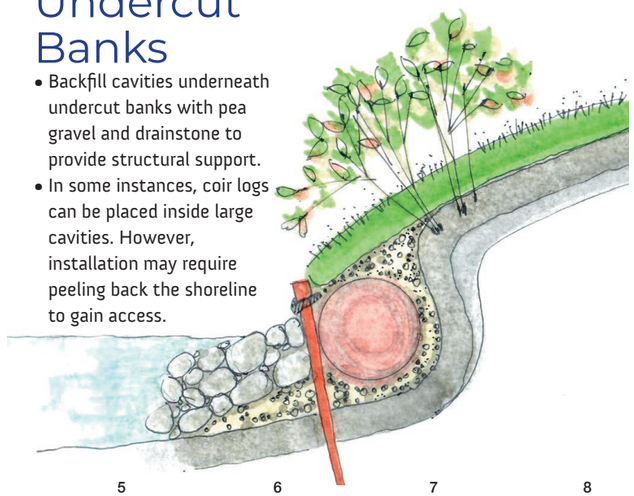
Alignment

Coir logs should be placed:

- As close to the shoreline as possible without creating sharp bends in the logs for every scallop and point.
- Relatively straight.
- Backfill voids between coir logs and shoreline where needed with pea gravel, drainstone and any additional soil amendments.
- Carefully avoid significant tree root disturbance.

Undercut Banks

- Backfill cavities underneath undercut banks with pea gravel and drainstone to provide structural support.
- In some instances, coir logs can be placed inside large cavities. However, installation may require peeling back the shoreline to gain access.



Native Plantings

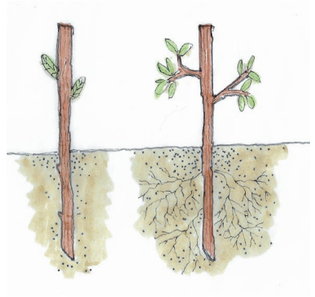
Selecting, installing, and maintaining native vegetation is a required component of bioengineering.

For best success for creating a root system that will hold the soil in place and fortify the shoreline choose:

- native species (not cultivars) that already grow around the lake or in the region from native plant nurseries.
- a combination of sedges, grasses, rushes, flowering perennials, shrubs, and trees.

Live Stakes

Cut branches from dormant woody shrubs approximately 3' long with a 1" diameter. Each stake should have several buds and nodes as these will form roots and new branches. Cut one end of the stake to a sharp point to help push it into the ground. Pre-drill a planting hole by hammering a piece of rebar into the ground or use an auger. Plant them as soon as possible after cutting them or receiving them from supplier. Keep stakes moist and cool while storing.



Live Stakes

PLANTING TIPS

Consider project budget, site conditions and design, plant availability, and client goals when selecting type of plant stock to use. Plantings should extend landward according to zoning ordinances. If ordinances are not applicable then plantings should extend a minimum of 6', though wider will be more effective.

- If needed, amend soils with compost.
- Use a biodegradable erosion control blanket to prevent erosion and retain moisture.
- Ideally, plant within and behind the coir log and on the land.
- Spacing should be according to species however, plugs are typically planted 12"- 18" on-center.
- Where appropriate, apply mulch.
- Choose plant stock type that best fits the site design and *homeowner goals.*

Estimating Volumes of Materials

Coir Log Size	Cross-Sectional Area of Coir Log	Volume of Field Stone per Linear foot V = H x D x L x 0.5 per linear foot *Slope of installation*	
	$A = \pi \times r^2$	4' horizontal: 1'vertical	5' horizontal: 1'vertical
12" diameter (6" radius)	A= 3.14159 x 36	12" x 48" x 12" x 0.5	12" x 60" x 12" x 0.5
	113.1 in^2 0.785 ft^2 0.087 yds^2	3,456 in^3 2 ft^3 0.07 yds^3	4,320 in^3 2.5 ft^3 0.09 yds^3
16" diameter (8" radius)	A= 3.14159 x 64	16" x 64" x 12" x 0.5	16" x 80" x 12" x 0.5
	201 in^2 1.4 ft^2 0.16 yds^2	6,144 in^3 3.5 ft^3 0.13 yds^3	7,680 in^3 4.4 ft^3 0.16 yds^3
20" diameter (10" radius)	A = 3.14159 x 100	20" x 80" x 12" x 0.5	20" x 100" x 12" x .5
	314.2 in^2 2.18 ft^2 0.24 yds^2	9,600 in^3 5.5 ft^3 0.2 yds^3	12,000 ^{3} 6.9 ft^3 0.26 yds^3

These estimates for amount of field stone are per linear foot of shoreline.

Example: 100' shoreline
12" coir log
4'H:1'V slope
= 0.07 yds^3 per foot
Total: 100 ft x 0.07= 70 yds^3

**Reference the rock sizing information to determine the rock size distribution.*

**Approximately 1 ft^3 of pea stone/drain stone per linear foot.*

A = Area
r^2 = Radius squared
π = 3.14159
V = Volume
H = Height of coir log
D = Distance for the correct slope
L = Length of shoreline